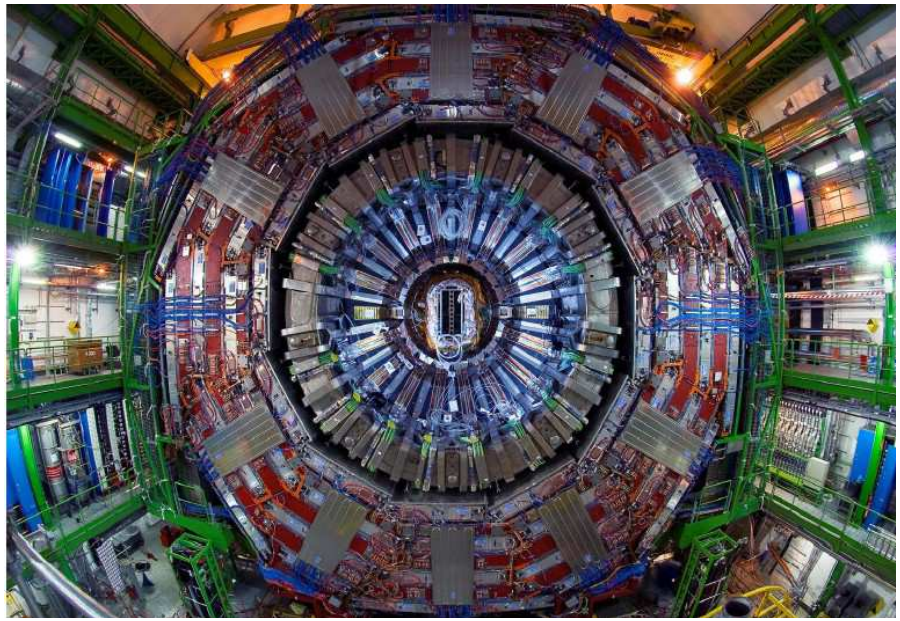
CMS Status and the Fermilab CMS Center



Jeffrey Berryhill/WF-CMS Center

FRA Physics Visiting Committee

April 25/26 2008

"Higgs first seen in CMS"

LHC Open Days April 5-6

50-70k showed up. 6000 escorted through CMS cavern!

Outline

- Status of CMS
  - CMS commissioning
  - The CMS physics program
- The Fermilab CMS Center
- Global Roles for CMS
  - Detector commissioning
  - Computing and software
  - Startup physics analysis
- Local Roles for US CMS
  - LHC Physics Center
  - LHC@FNAL remote operations

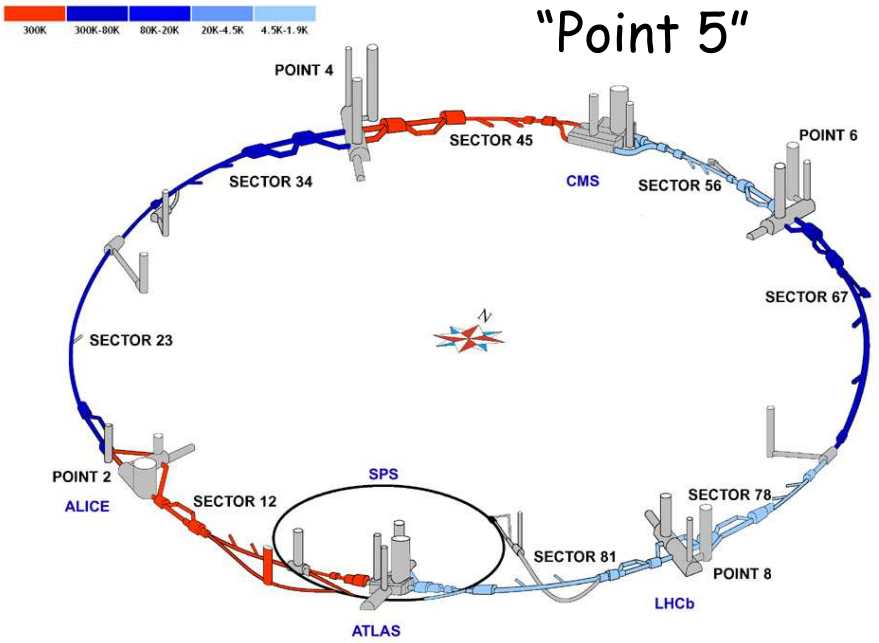
LHC Status

- LHC status: > halfway through final **cooldown, complete by June**, followed by checkout and **single beam commissioning to 5TeV**.

- **pp collisions as soon as this July starting at 10 TeV**. Proceed to design of 14 TeV once 7 TeV beam operations are reliable.

- LHC commissioning has top priority, experiments must conform to their schedule. CMS gets two months' notice to prepare for first beam.

CMS
"Point 5"



All light blue = time's up!

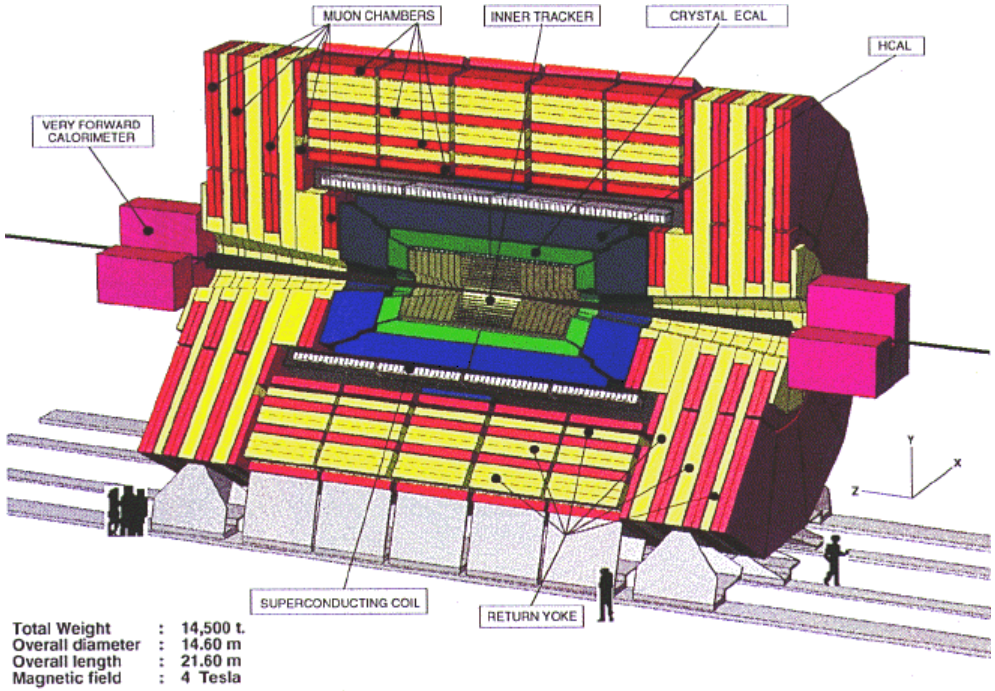
CMS Status

- **All heavy elements have been lowered** into the cavern
- All ECAL barrel modules installed
- **Si strip tracker lowered and inserted** last December. Ready for cosmic tests in May.
- **CMS solenoid is cold**, ready in June for 3.8 T operation.

- **All muon systems, HCAL, ECAL, trigger, and DAQ** have all undergone a series of cosmic tests in situ (**monthly "global runs"**)

- Central beam pipe section inserted in SiTracker

- **Ready to close with all these in July**



CMS Status

What is not yet in the cavern:

ECAL endcaps: delayed by crystal production, but **2/4 Dees at point 5 by mid June and 4/4 by end July**

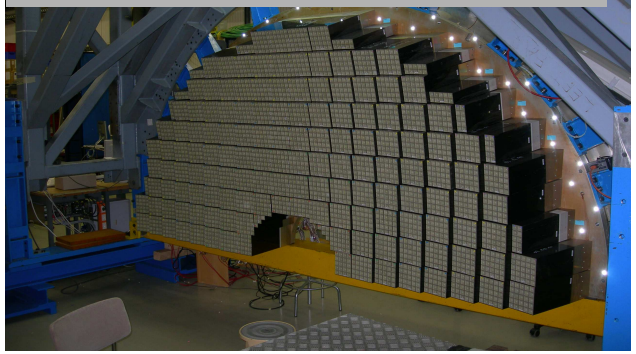
Barrel pixels: commissioning at PSI, delivery to CERN soon

Forward pixels: delivery to CERN complete; cosmic tests at TIF successful

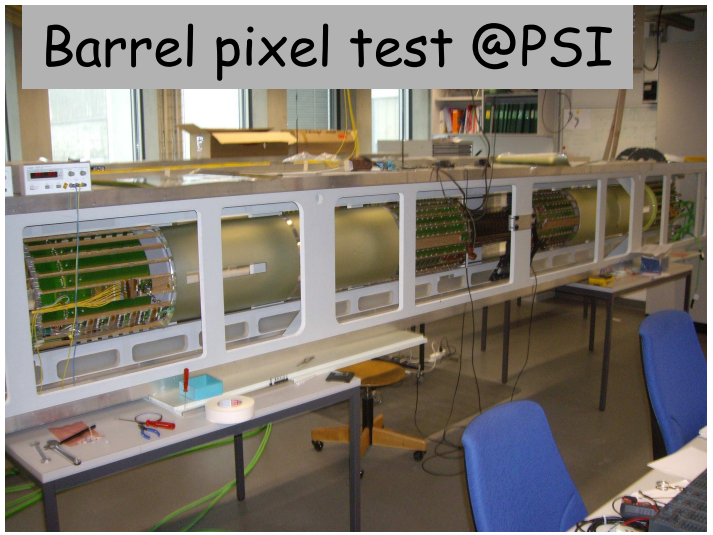
Pixel detector installation currently scheduled for last week of June

Beam-pipe installation and bakeout on the critical path

½ endcap with crystals



Barrel pixel test @PSI



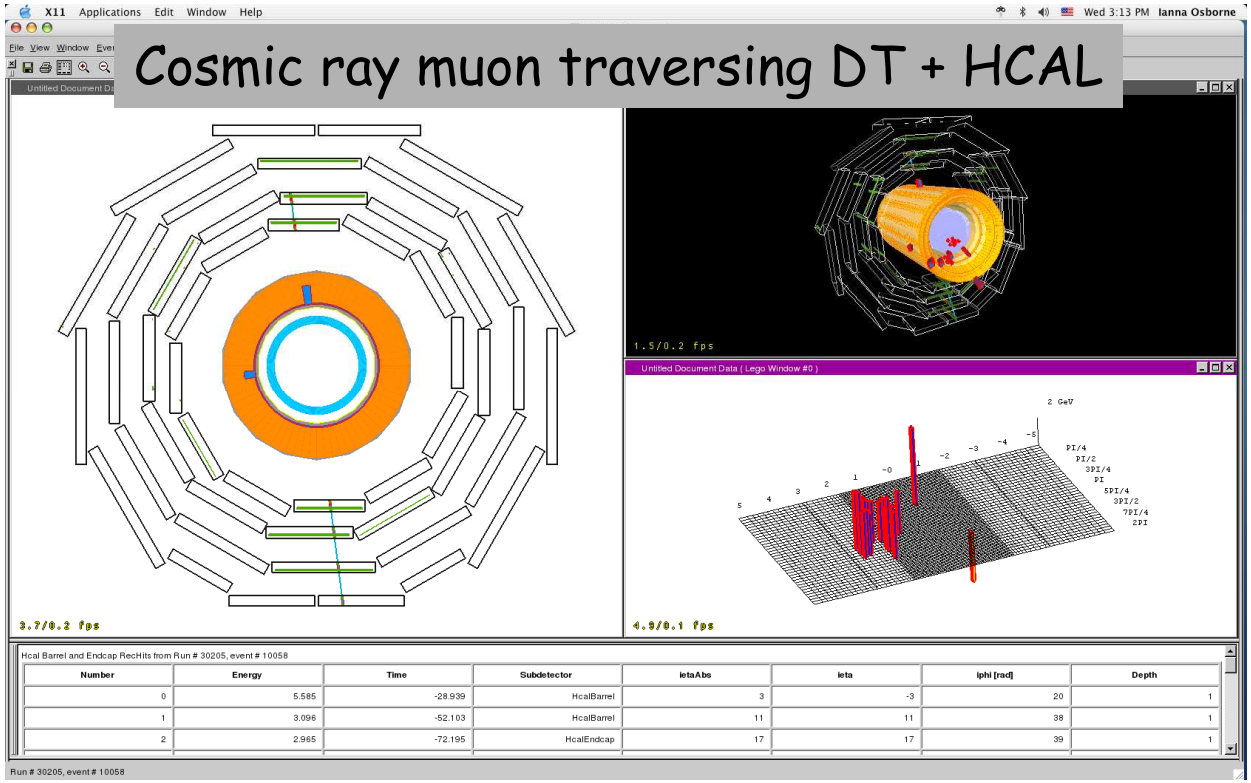
CMS Systems Integration

- Monthly coordinated operations exercises collecting cosmic ray data, reading out as many subdetectors as available with CMS L1 trigger & DAQ

Two more rounds of practice before pp collisions:

CRUZET (cosmic run at zero tesla) in May to include Tracker for 1st time

CRAFT (at four tesla) in late June/July to include magnet



Also: run startup trigger menu, run control, monitoring, 24/7 shift ops.

CMS Physics Program

2008

0-1 pb^{-1} calibration, alignment. Measurements of minimum bias pp and low PT leptons and jets.

1-10 pb^{-1} First cross section measurements: W, Z, high PT jets, top, calibration of high PT physics objects

2009

10-100 pb^{-1} Precision W/Z/top cross sections, diboson production + discovery potential in some channels (jets, CMSSM SUSY, TeV Z')

0.1-1 fb^{-1} **Discovery phase begins**: discovery over large range of channels and masses, SM Higgs evidence > 200 GeV

2010+

1-10 fb^{-1} SM Higgs discovery, high-mass BSM discovery

10-100 fb^{-1} precision BSM, or stingier scenarios (VBF); SLHC/upgrades

Also: B physics, heavy ion physics, and forward physics

Possible 2008 Run Plan

- Approximately 30 days of beam to establish first collisions
- Pushing gradually one or all of:
  - Bunches per beam (1 to 43 to 156)
  - Squeeze
  - Bunch Intensity

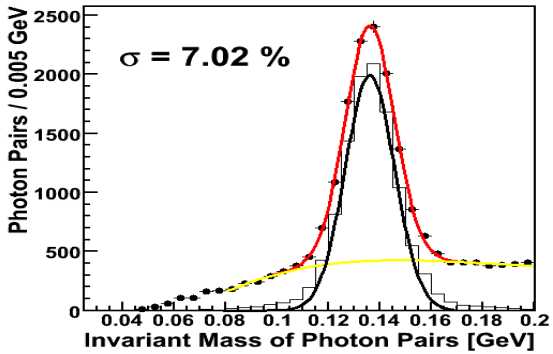
IP 1 & 5

	Bunches	β*	I_b	Luminosity	Pileup	Min. bias rate	$\int L\,dt$:
Aug?	1 x 1	18	10^{10}	10^{27}	Low	55 in ~10^4 xings	
	43 x 43	18	3 x 10^{10}	3.8 x 10^{29}	0.05	20 kHz in 5.10^5	
	43 x 43	4	3 x 10^{10}	1.7 x 10^{30}	0.21	60 kHz in 5.10^5	~ 0.1 pb^{-1}
	43 x 43	2	4 x 10^{10}	6.1 x 10^{30}	0.76	200 kHz in 5.10^5	
Sep?	156 x 156	4	4 x 10^{10}	1.1 x 10^{31}	0.38	400 kHz in ~10^7	~ 1 pb^{-1}
	156 x 156	4	9 x 10^{10}	5.6 x10^{31}	1.9	2MHz in ~10^7	
Oct?	156 x 156	2	9 x 10^{10}	1.1 x10^{32}	3.9	4MHz in ~10^7	~ 10 pb^{-1}

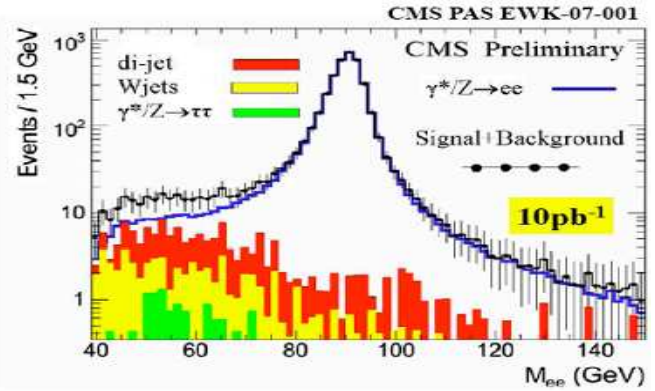
CMS Physics Program

- Current emphasis in CMS physics groups is **startup/calibration studies** in the 1 pb^{-1} epoch followed by "**re-discovery of the standard model**" in the 10 pb^{-1} epoch

  - ECAL and HCAL intercalibration, high PT object energy scale
  - Tracker and muon alignment, momentum scale
  - Minimum bias particle flow
  - J/psi and Upsilon dimuons
  - Inclusive jet and dijets
  - W/Z production
  - top pair production



From π^0 ....



...to Z^0

- **iCSA08 challenge**: In May, a **final rehearsal** meant to simulate these studies; including use of planned trigger menu and data operations, with real time analysis teams at CERN and Tier2's

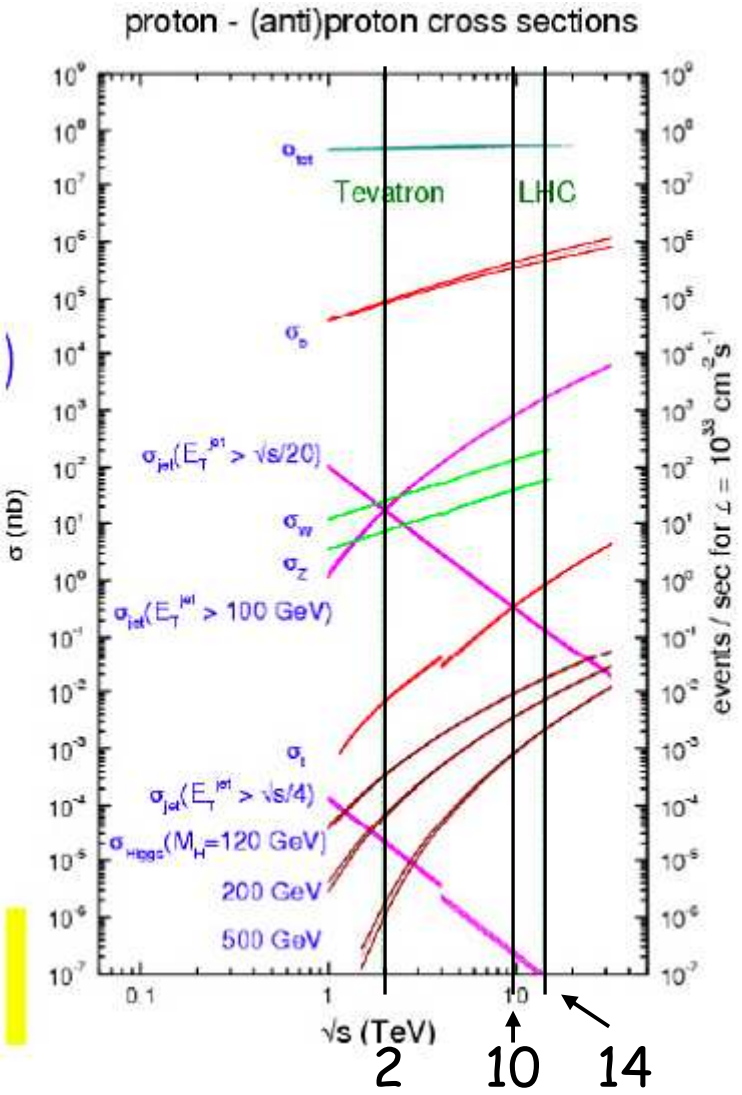
10 TeV vs. 14 TeV

Running at 10 TeV instead of 14 TeV degrades cross sections of processes far from the LHC kinematic limit by **about a factor 2**

The main consequence in the short term is that twice as much luminosity is required to achieve the same goals at 10 TeV as it would have at 14 TeV

Discovery potential is largely maintained even with a (unplanned) prolonged running period at 10 TeV

"Ultimate" mass reach is degraded but that epoch is far off from now.



The Fermilab CMS Center

- An organizational unit within Fermilab containing all CMS-related resources
  - Cross-divisional (PPD,CD)
  - and cross-institutional (FNAL, USCMS, US Unis, foreign visitors)
  - Reports to Assoc. Director for Research (à la PPD or CD)
  - Headed by **Lothar Bauerdick** since its creation in late 2006
- Sub-units
  - LHC Physics Center (LPC)
  - Remote Operations Center (ROC)
  - CMS Tier-1 Computing and Analysis Facilities (LPC-CAF)
  - Research Program Management and Program Office
  - Fermilab CMS group (scientists, Wilson Fellows, and postdocs)
- CMS Center Management Members:
  - CMS Center Director, PPD Liaison, CD Liaison
  - US CMS Research Program Manager, S&C, M&O
  - LPC Coordinators
  - meeting on a weekly basis

The Fermilab CMS Center

CMS Center Mission

- **provide overall coordination and management** of the Fermilab contributions to CMS and the resources invested in CMS
- ensure that Fermilab and U.S. CMS **enables U.S. physicists to fully and actively participate** in the science made available at the LHC

Goals

- **enhance U.S. ability** to perform LHC-based research
- **attract physicists to FNAL** during the LHC era
- **facilitate collaboration** between FNAL and research performed elsewhere

The Fermilab CMS Center

Core composition:
40+ FNAL scientists
1 Wilson Fellow
9 Postdocs
5 Guest scientists
7 Visiting scientists

~10 personnel based at CERN

Contributing to CMS in virtually all aspects, with large efforts in:
HCAL,
Tracking/Pixels,
Tier 1 Computing,
Offline/Physics software

CMS Center Organizational Chart (11/2007)

CMS Center Management
BAUERDICK, Lothar A.T. - CMS Center Director
BUTLER, Joel - U.S. CMS Research Program
FISK Ian - U.S. CMS Software and Computing
FREEMAN Jim - U.S. CMS Maintenance and Operations
GREEN Daniel - PPD, LHC Physics Center
MCBRIDE Patricia - CD
TULLY Chris - LHC Physics Center

Detectors

DAQ
O'DELL Vivian - PPD
SUZUKI Ichiro (CP) - PPD

HCAL
ALBROW Michael - PPD
ELIAS John E - PPD
FREEMAN Jim - PPD
GREEN Dan - PPD
HANLON Jim - PPD
KOUSOURIS, K. RA - CC
VIDAL Richard - PPD
WHITMORE Juliana - PPD
WU Wei Min - PPD
Piperov Stefan (CS) - CC

Muons
APOLLINARI Giorgio - TD
GEURTS Frank J.M - PPD
BORCHERDING Fred - PPD
EARTLY David - PPD
YARBA Viktor - PPD

Pixels
ATAC Muzaffer - PPD
BALDIN Boris (E) - PPD
BHAT Pushpalatha - PPD
(BUTLER Joel Nathan) - PPD
HAHN Alan - PPD
JOSHI Umesh - PPD
KWAN Simon - PPD
LOS Serguei (E) - PPD
NEWMAN-HOLMES C - PPD
TAN Ping RA - CC
UPLEGGER Lorenzo RA - CC

SiTracker
DEMARTEAU Marcel - PPD
JENSEN Hans - PPD
NOEDING Carsten RA - CC
SPALDING William J - PPD
SPIEGEL Leonard - PPD
TKACZYK Slawek - PPD
MOCCIA Stefano (E) - PPD

Physics Software

Muon reco
BLOCH Ingo RA - CC
JAMES Eric - PPD

Tracking reco
BURKETT Kevin - PPD
GUTSCHE Oliver RA - CC
YUMICEVA Francisco RA - CC

HCAL reco
ELVIRA Victor Daniel - CD
HARRIS Robert - CD
KURT (VS) - CC
TOPOLKI (VS) -- CC

Simulations
Banerjee, Sunanda - CD
BOSE (VS) - CC
ELVIRA Victor Daniel - CD
YARBA Julia (CP) - CD
MRENNA Stephen - CD
SHARMA (VS) - CC

DQM and Trigger
BERRYHILL Jeffrey WF - CC
CHLEBANA Frank - PPD
MAESHIMA Kaori - PPD
BADGETT William (CP) - PPD

Core Software
CHEUNG Harry - PPD
DAGENHART Dave (CP) - CD
JONES Chris (CS) - CD
KOWALKOWSKI James (CP) - CD
PATERNO Marc (CP) - CD
SEXTON-KENNEDY (CP) - CD
TANENBAUM William (CP) - CD

Distributed Applications
AFAQ M Anzar (CP) - CD
BLUMENFELD Barry (CS) - CD
DYKSTRA David (CP) - CD
EVANS David (CP) - CD
GUO Yuyi (CP) - CD
LUEKING Lee - CD
LUKHANIN Gennadiy (CP) - PPD
SEKHRI Vijay (CP) - CD
WICKLUND Eric - CD

Physics Infrastructure

Computing Facilities Tier-1, LPC-CAF, Grids
ALBERTS Marina (CP) - CD
BAKKEN Jon Alan (CP) - CD
FAGAN David (CP) - CD
GAINES Irwin - CD
HESSELROTH Ted (CP) - CD
HOLZMAN Burt (CP) - CD
KAISER Joseph (CP) - CD
PETRAVICK Donald (CP) - CD
PORDES Ruth (CP) - CD
SFILIGOI Igor (CP) - CD
STIEHR Gary (CP) - CD
WU Yujun (CP) - CD

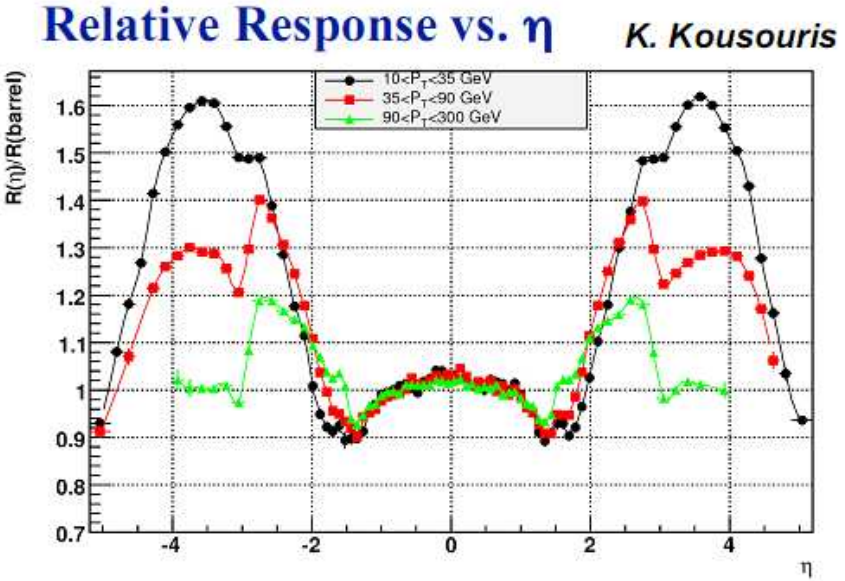
Offline Infrastructure
BAUERDICK Lothar A.T - CC
FISK Ian - CD
GUTSCHE Oliver - CC
KLIMA Boaz - PPD
MASON David - CC
MCBRIDE Patricia - CD
ABDULLIN Salavat (CP) - PPD
GARTUNG Patrick (CP) - CD
MARRAFFINO John - CD
RATNIKOVA Natalia (CP) - CD
(SEXTON-KENNEDY)(CP) - CD

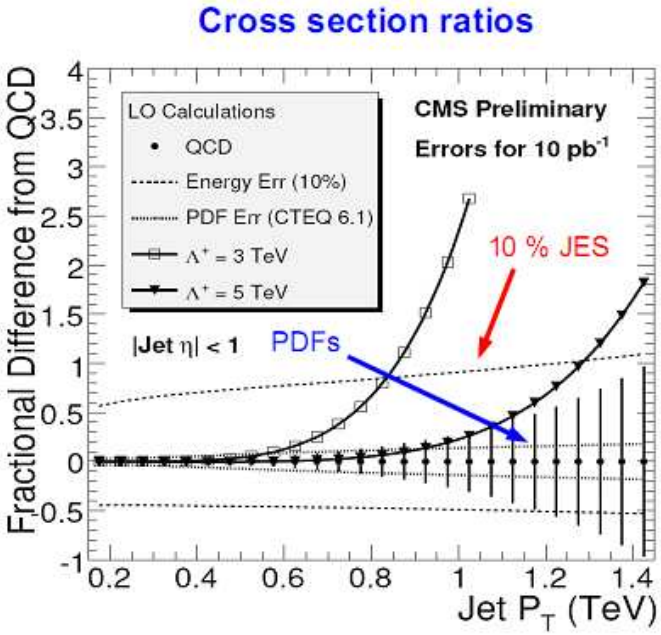
Centers & Offices

LHC Physics Center
GREEN Dan - PPD
TULLY Chris - PrincetonU
Remote Operations Center
COTTSCHALK Erik - PPD
MAESHIMA Kaori - PPD
STONE Alan Lee (CP) - PPD
MOKHOV Nikolai - AD
Research Program Office
BUTLER Joel Nathan - PPD
(FISK Ian) - CD
(BAUERDICK Lothar A.T) - CC
(FREEMAN Jim) - PPD
DOODY Tim (CP) - CD
HANLON Jim (CP) - PPD
KRAMER Tami (CP) - PPD
LUSIN Sergei (E) - PPD
NAHN Jen OC - CD
Admin Support
Carrie Farver - PPD
Terry Grozis - PPD
Terry Read - PPD

Global Roles for CMS: HCAL and JetMET

- Instrumental in HF construction and US HCAL RPM
- Now active in jet reconstruction and calibration with first CMS data (CMS JetMET group)





Detailed plans for:
HCAL & Jet energy corrections

HCAL simulation tuning and offline software validation

Early (10 pb^{-1} !) discovery potential with first jet data

Global Roles for CMS: Tracking

- Fermilab instrumental in TOB and Forward Pixel construction
- Successful cosmic ray commissioning tests (local and remote) at the CERN Tracker Integration Facility
- Intense commissioning phase to commence at point 5 next month for SiTracker, Pix soon to follow

US CMS TIF team @CERN

CMS FPIX team

Global Roles for CMS: Tier 1 Computing

FNAL is the largest Tier-1 center in CMS ("the canonical Tier 1")

- One of 7 in all of CMS
- The only Tier-1 center in the Americas
- The center will reach 6MSI2k, 2PB of disk, 4.7PB tape
- WAN network is 20Gb/s

LPC-CAF also serves as the equivalent of a Tier 2 center for FNAL-based physics analysis

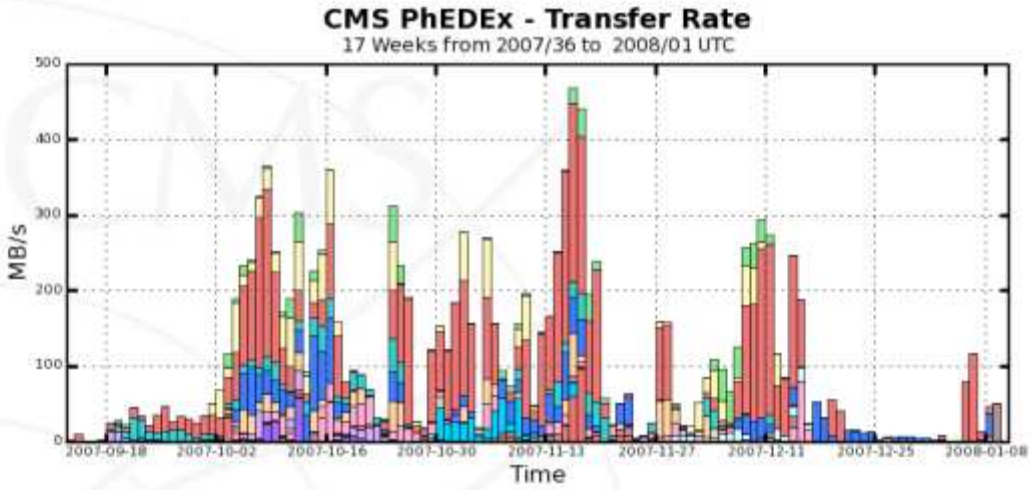
Also:

Open Science Grid participation

Offline release validation sample production

CMS Remote Analysis Builder for GRID computing (CRAB)

Sustained xfers from T0 at few 100 MB/s



Global Roles for CMS: Offline Software

- Core CMS offline software (CMSSW) development
  - Configurable, modular analysis framework
  - Event data model definition and features
  - Training and support for physics analysis software, for normal and novel uses
  - Software release creation and validation

- Physics Analysis Toolkit development
  - New initiative to consolidate and simplify physics object selection and composition
  - Starter Kit to rapidly get to plot-making
  - Common tools to match, select, reweight objects
  - Prescribed interface for most CMS analysis

..as seen in Symmetry magazine

Global Roles for CMS: Many others

- DAQ commissioning
- Data storage manager commissioning
- CSC commissioning
- W, Z, and top analysis
- Lepton efficiency and fake rate measurements
- B-tagging efficiency and beam-spot monitoring
- Trigger monitoring software
- Database development
- …

- Leverage commissioning of detector/physics objects to jump to high-value, discovery physics participation
  - ➢ alongside natural allies within USCMS/LPC

Global Roles for CMS: Leadership

- Fermilab CMS Center membership is directly involved in international CMS leadership, in addition to many US CMS responsibilities

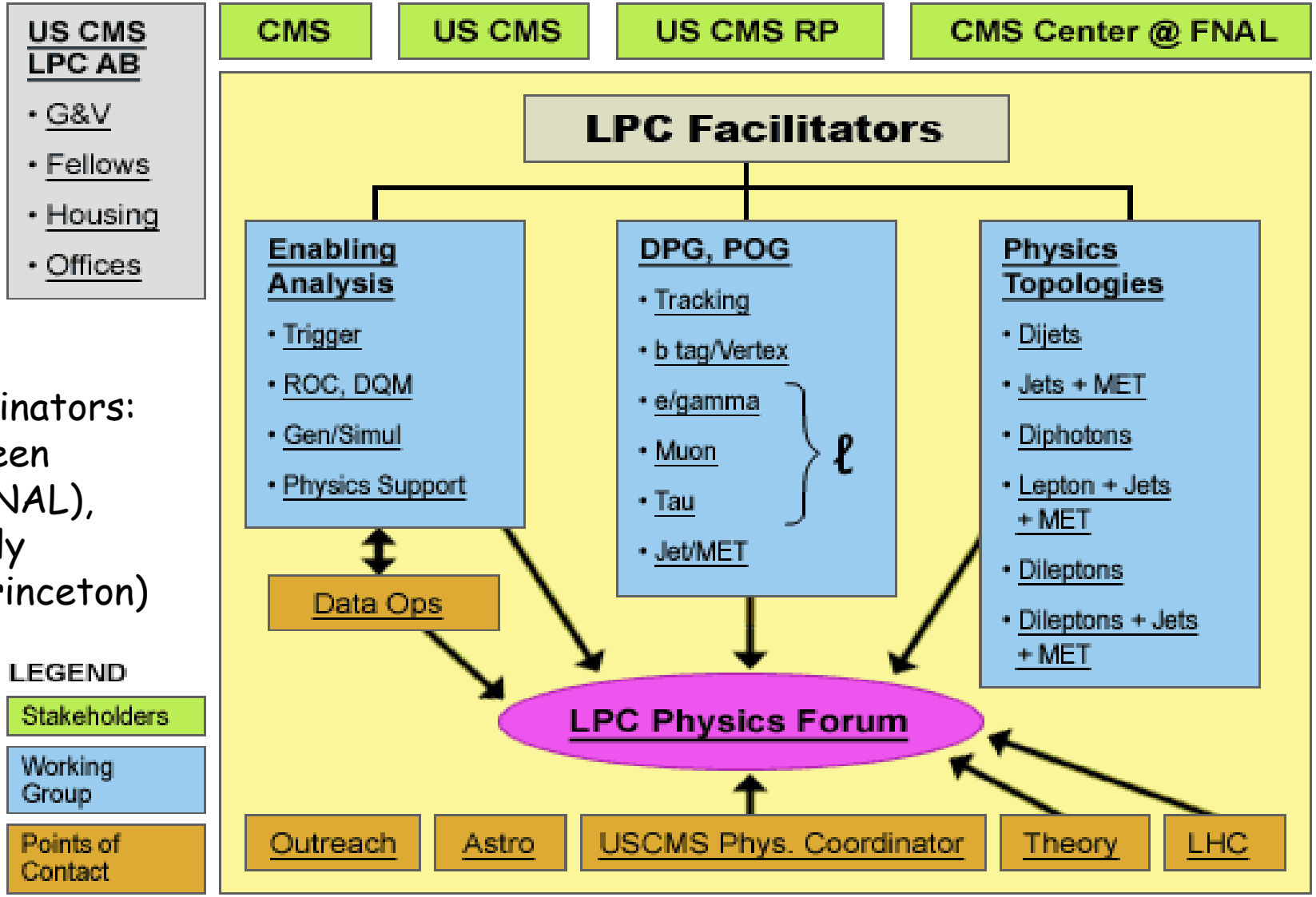
Non-exhaustive list:

- CMS Collaboration Board Chair (D. Green)
- CMS Computing Coordinator (P. McBride)
- CMS Jet/MET Physics Object Group Convener (D. Elvira)
- Several CMS offline software coordination roles
  - CMSSW Framework (L. Sexton-Kennedy)
  - Computing Integration (I. Fisk)
  - Data/Workflow management (D. Evans)
  - Tracking reconstruction (K. Burkett)
- Leadership in US CMS
  - HCAL (J. Whitmore)
  - Operations (K. Maeshima)
  - Physics leadership roles for US CMS via LPC

The LHC Physics Center

- A "brick and mortar" location for CMS physicists to consult each other, formally and informally, in US time zones
- A place for workshops/conferences/gatherings on LHC physics.
- A place for the training of graduate and postgraduate scientists.
- A "remote operations center" that CMS physicists can use to participate in data taking and quality control for CMS
- An organization to facilitate communication between US CMS and Int'l CMS

The LHC Physics Center



LPC Coordinators:
D. Green (FNAL),
C. Tully (Princeton)

LPC by the numbers

- **~100 core members**, 50/50 FNAL/University
- **+ 100 more transient** residents
- **28 universities** have offices spanning all of WH11 and ½ of WH10
- ~40 designated experts within US CMS to help connect physicists with valuable projects within Int'l CMS
- 5 fully equipped videoconference rooms (near full occupancy)
- "Hotel" workspace for ~20 desktops + ~20 more seats for wireless
- 850 presentations over **120 unique meeting events** over the last year!

Recent and Recurring LPC Events

- "JTerm" : Annual January CMS 101 bootcamp for CMS newcomers. Other tutorials throughout the year as demanded by US CMS community.
- LPC Physics Forum: Biweekly forum to showcase recent US CMS physics studies to a US audience (including theorists)
- CMS Physics Workshops in June and October 2007: Kickoff of LPC physics topology groups (>200 registrants)
- US CMS Run Plan Workshop May 15-16: Practical planning for first CMS operations, detector calibration, and analysis



LPC Physics Forum: Who is watching?

Physics Forum (Recent Visitor Map) 9th April 2008 11:30:00

Pages (2): [[1] 2]

LHC@FNAL Remote Operations Center

- CMS is an inherently "remote" experiment:
  - ~30 min from main lab
  - Site is minimally equipped with office space and control room seats
  - Most manpower for online monitoring "offsite"
- Both CERN-based and Int'l CMS users need well-equipped centers for coordinating the remote, offsite operations manpower

LHC@FNAL Remote Operations Center

- The Fermilab CMS Center took the initiative to create a remote monitoring center fulfilling this need for US CMS:

LHC @ FNAL Remote Operations Center

- A communications hub for operations tasks between US and CERN:
  - LHC operations
  - Tier 1 data operations
  - Detector status and data quality
  - **Official shift-taking**

- A development center for operations software
- A visible center of activity for Fermilab/CMS outreach and education

LHC@FNAL Communications Functions

- Headquarters for USCMS operations group and LPC ROC team (K.Maeshima, N. Hadley)
- Meetings of local accelerator physicists with LHC; Tier 1 with CMS computing
- Live monitoring of CMS commissioning runs
- 2 Polycom video stations plus adjoining conference room

LPC ROC Team

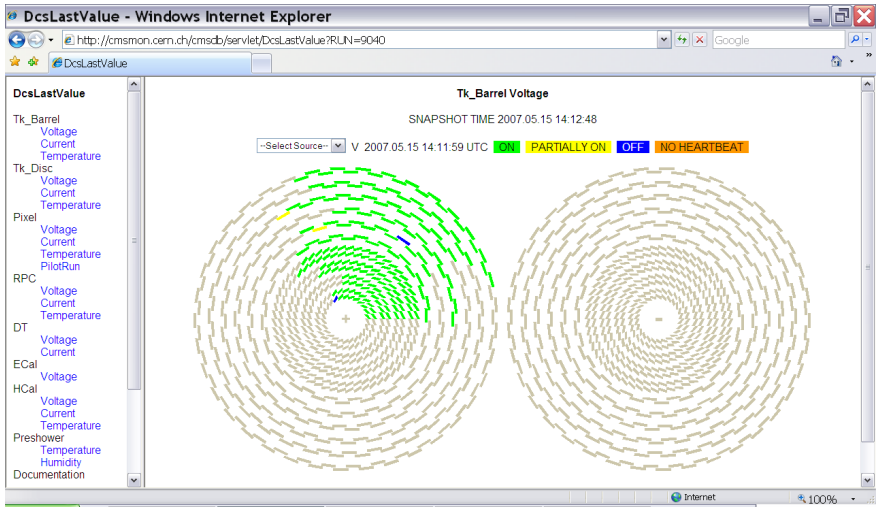
CMS centre @ CERN

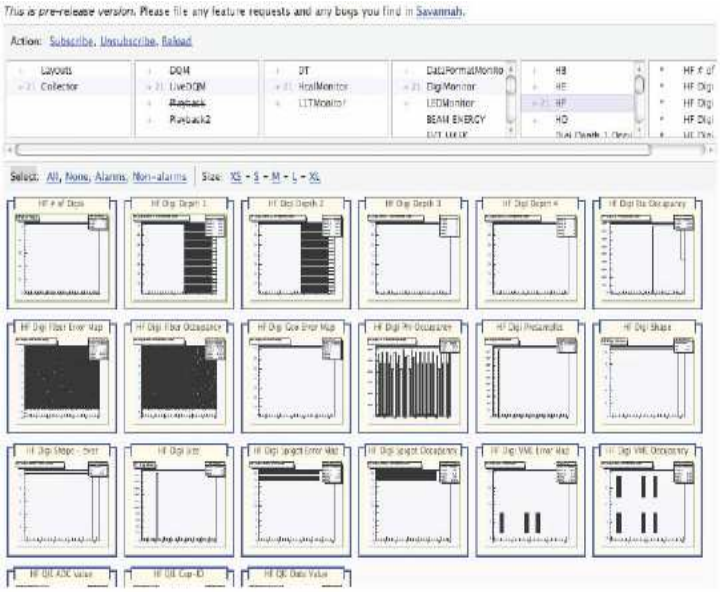
- Continuous video connection with Point 5 control room and the CMS remote operations center at CERN

- Web-based software for a host of live, remote monitoring applications

LHC@FNAL Software Development

- CD & PPD co-development of web-based monitoring tools:
  - Screen snapshot service
  - Web-based monitoring
  - Data discovery
  - CMS Page 1
- US CMS development of online and offline DQM software of CMS data
  - HCAL
  - Tracker
  - Trigger
  - Offline reconstruction





Concluding Points

- CMS commissioning is **in its final stages** and will be ready for **pp collision physics in 2008**. 100% installation is tight for a 2008 run (EE,PIX) but a near certainty for 2009.

- The CMS physics research program is focused on **calibration and SM re-discovery** in the short term, transitioning to **an unprecedented discovery phase** when we cross ~100 pb^{-1} (or possibly less).

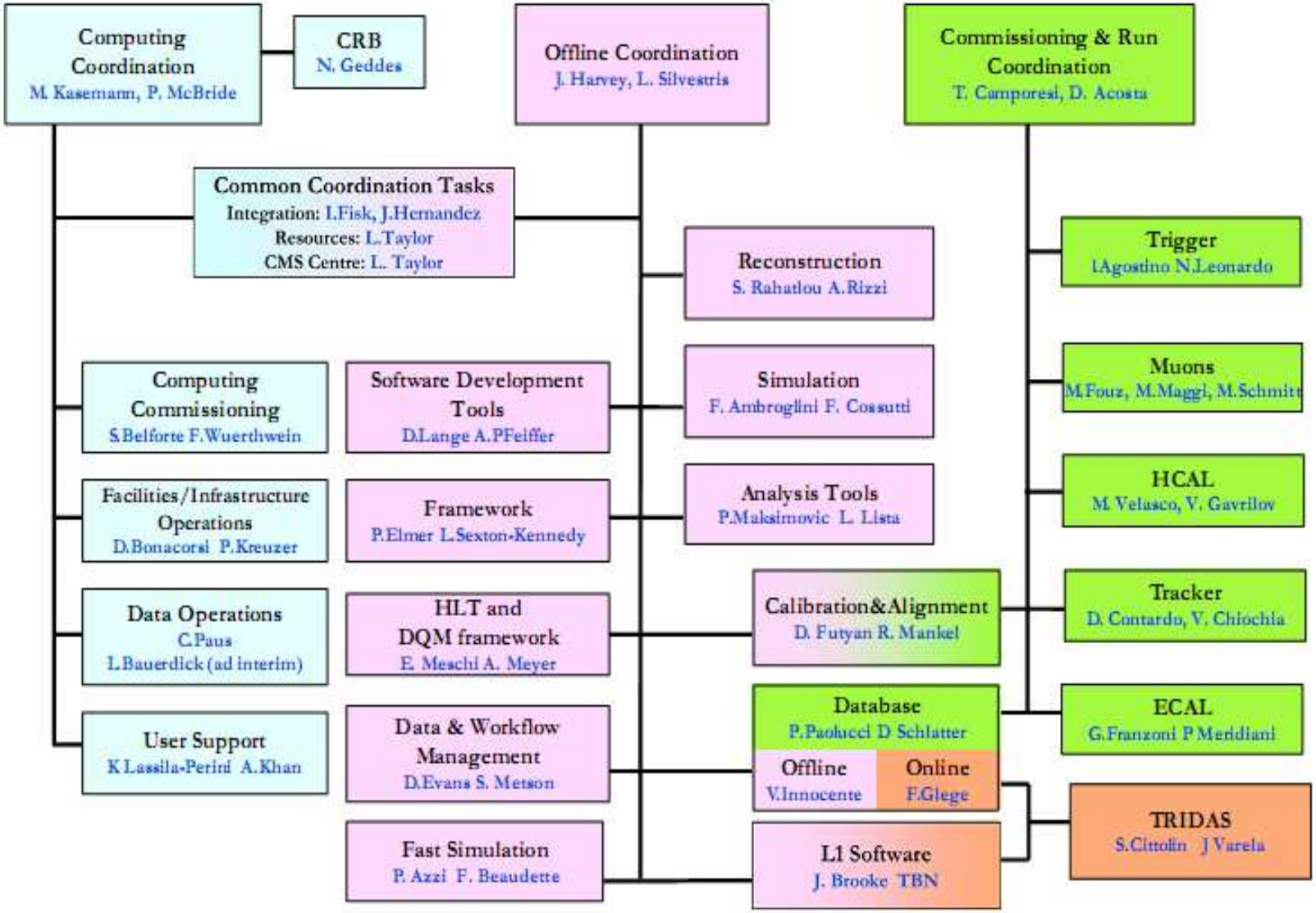
- The Fermilab CMS Center has **a unique concentration of leadership and expertise**, we are an essential resource for CMS as a whole.

- International scope of **CMS requires regional organization** and distributed means for physics analysis and detector operations. The Fermilab CMS Center is the leader in this transition and the **bedrock of support for US CMS institutions.**

LPC Governance

- Committee report advising on LPC structure and leadership
  - representation from USCMS, CMS, LPC, LPC-AB, CMS-CB
- Principal Recommendations
  - LPC to be led by two LPC Coordinators with staggered two-year terms
  - LPC Coordinator Selection Committee, identify short ranked list
    - candidates nominated by the U.S. CMS Collaboration
    - Fermilab Director to appoint the LPC Coordinators from the short list
  - LPC Management Board LPC-MB
    - chaired by the LPC Coordinators, to direct the LPC program of work, to draw up policies and to provide the forum for close coordination with activities in CMS, in U.S. CMS, and in the CMS Center.
  - LPC Advisory Board LPC-AB
    - provide advice to the LPC Coordinators, give regular feedback on LPC performance to the LPC-MB and report to the U.S. CMS Collaboration and Fermilab

BACKUP SLIDES



BACKUP SLIDES